(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 146 344 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.10.2001 Bulletin 2001/42

(51) Int Cl.7: **G01R 31/36**

(21) Application number: **01108602.2**

(22) Date of filing: **05.04.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **10.04.2000 JP 2000108672**

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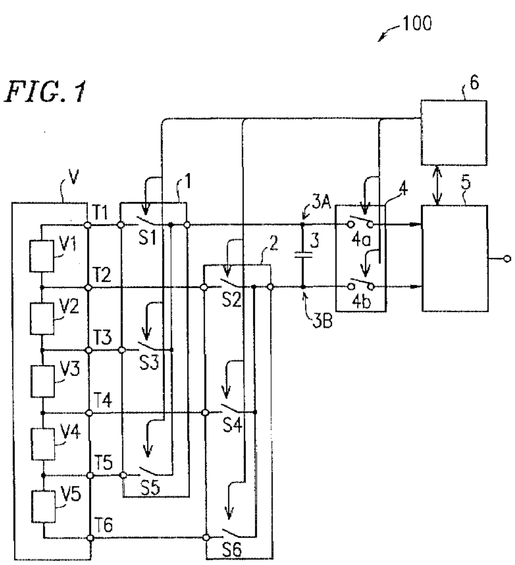
(54) **Multiplex voltage measurement apparatus**

(57) A multiplex voltage measurement apparatus includes :
(N+1) voltage detection terminals connected to N serially connected voltage sources; a capacitor which is charged with a voltage value of any of the N voltage sources; a first sample switch for selectively connecting odd-numbered voltage detection terminals among the (N+1) voltage detection terminals to a first terminal of the capacitor; a second sample switch for selectively connecting even-numbered voltage detection terminals among the (N+1) voltage detection terminals to a second terminal of the capacitor; a voltage measurement circuit for measuring the voltage value stored in the capacitor; a third sample switch for connecting the first terminal and the second terminal of the capacitor to the voltage measurement circuit; and a polarity controller for controlling the first and second sample switches such that one of the N voltage sources is selected while the third sample switch is open.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION:

[0001] The present invention relates to a multiplex voltage measurement apparatus, and specifically to a multiplex voltage measurement apparatus for measuring a voltage of each of serially connected N voltage sources.

2. DESCRIPTION OF THE RELATED ART:

[0002] A high-power electric source of several hundred voltages for an electric vehicle is formed by a number of secondary battery cells, such as nickel-hydrogen storage cells, which are serially connected to each other. Each of the serially connected battery cells should be monitored for its capacity for the purpose of charge/discharge control.

[0003] In particular, a battery formed by 240 serially connected cells produces a total voltage of 288 V. In such a battery, it is physically difficult to monitor each cell. In Japanese Laid-Open Publication No. 8-140204, for example, the voltage is measured for each of 24 modules each including 10 cells.

[0004] In an electric vehicle, high-voltage systems are electrically insulated from a chassis in order to avoid hazardous conditions. On the other hand, since a processor for charge/discharge control uses a potential of the chassis as a reference potential, the voltage of a battery should be insulatively measured.

[0005] In the battery disclosed in Japanese Laid-Open Publication No. 8-140204, an insulation circuit unit including an operational amplifier, an AD converter, a photocoupler, a power supply, etc., is provided for each module. The structure of such a battery is enormously complicated.

[0006] As means of insulatively measuring the output voltage of a sensor or the like, a flying capacitor is known. Figure **3** shows a structure of a multiplex voltage measurement apparatus **300.** In this example, the number of voltage sources **(N)** is 5.

[0007] Serially-connected voltage sources **V1-V5** are connected to a capacitor **3** through voltage detection terminals **T1-T6,** and through a first sample switch **1** formed by switches **S1**, **S3**, and **S5** and a second sample switch **2** formed by switches **S2, S4,** and **S6.** The capacitor **3** is connected to a voltage measurement circuit **5** through a third sample switch **4** formed by switches **4a** and **4b.**

[0008] Figure **4** is a timing chart for opening/closure of the respective switches **S1-S6,** and **4a** and **4b**. An operation of the multiplex voltage measurement apparatus **300** is now described with reference to Figure **4** in conjunction with Figure **3.**

[0009] Prior to measuring the voltages of the voltage sources **V1-V5,** the switches **S1-S6,** and **4a** and **4b** are all opened (OFF). During period P1, first of all, the switches **S1** and **S2** are closed (ON), whereby the voltage of the voltage source **V1** is applied to the capacitor **3,** and a charge is stored in the capacitor **3.** After being kept closed (ON) for a predetermined time period, the switches **S1** and **S2** are turned off. Then, after a predetermined time has elapsed since the switches **S1** and **S2** were turned off, the third sample switch **4** (switches **4a** and **4b**) is turned on, whereby the charged voltage in the capacitor **3**, i.e., the voltage of the voltage source **V1,** is transferred to the voltage measurement circuit **5.**

[0010] As a matter of course, a driving circuit of each switch and a contact point of the switch are kept separated. The first sample switch **1** is not closed while the third sample switch **4** is closed, and the second sample switch **2** is not closed while the third sample switch **4** is closed. Therefore, the voltage of the voltage source **V1** is insulatively measured, i.e., when the voltage of the voltage source **V1** is measured, the voltage source **V1** and the capacitor **3** are insulated.

[0011] During period P2, the switches **S2** and **S3** and the switches **4a** and **4b** are similarly turned on and off, and during period P3, the switches **S3** and **S4** and the switches **4a** and **4b** are similarly turned on and off. In this way, as shown in Figure **4,** the multiplex voltage measurement apparatus **300** operates in a multiplex manner to measure the voltage values of the voltage sources **V1-V5**.

[0012] In the above structure of the conventional voltage measurement apparatus, when measuring the voltage source **V1** after the voltage source **V5** has been measured, the switches **S1** and **S2** are closed (ON). However, if one of the switches **S1** and **S2** is out of order, e.g., one of the switches **S1** and **S2** which should be closed is left opened, the voltage of the voltage source **V1** cannot be stored in the capacitor **3,** and the charge in the capacitor **3** which was stored when the voltage source **V5** was measured remains in the capacitor **3.** Since the polarity of the capacitor **3** when the voltage of the voltage source **V1** is measured is the same as that when the voltage of the voltage source **V5** is measured, the voltage measurement apparatus **300** erroneously reads the voltage of the voltage source **V5**.

[0013] Thus, when one of the switches **S1** and **S2** is out of order so that it cannot be closed, the previously stored charge is left in the capacitor **3.** Therefore, the voltage measurement apparatus **300** erroneously reads the voltage left in the capacitor **3,** and cannot detect the failure which may cause such an erroneous measurement.

SUMMARY OF THE INVENTION

[0014] According to one aspect of the present invention, a multiplex voltage measurement apparatus includes: (N+1) voltage detection terminals connected to N serially connected voltage sources; a capacitor which

is charged with a voltage value of any of the N voltage sources; a first sample switch for selectively connecting odd-numbered voltage detection terminals among the (N+1) voltage detection terminals to a first terminal of the capacitor; a second sample switch for selectively connecting even-numbered voltage detection terminals among the (N+1) voltage detection terminals to a second terminal of the capacitor; a voltage measurement circuit for measuring the voltage value stored in the capacitor; a third sample switch for connecting the first terminal and the second terminal of the capacitor to the voltage measurement circuit; and a polarity controller for controlling the first and second sample switches such that one of the N voltage sources is selected while the third sample switch is open.

[0015] In one embodiment of the present invention, the polarity controller allows the first and second sample switches to sequentially select among the N voltage sources in a one-by-one manner such that the capacitor is alternately charged with voltage values having opposite polarities.

[0016] According to the present invention, when the voltages of voltage sources are sequentially measured, voltages having opposite polarities, i.e., positive voltages and negative voltages, are alternately applied to a capacitor. With such an arrangement, even when a first sample switch or a second sample switch is out of order so that it cannot be closed, and the voltage measured at a previous measurement remains in the capacitor, the voltage measurement apparatus can determine that there is a broken switch because a voltage measurement apparatus obtains voltage values of the same polarity in succession.

[0017] Thus, the present invention is characterized in that a voltage measurement apparatus includes a polarity controller for allowing the sample switches to sequentially select the voltage sources such that voltages having opposite polarities are alternately stored in the capacitor.

[0018] Thus, the invention described herein makes possible the advantages of (1) providing a multiplex voltage measurement apparatus which does not measure an erroneous voltage even when one of sample switches is out of order so that it cannot be closed; and (2) providing a multiplex voltage measurement apparatus which can detect a failure in an operation of one of the sample switches.

[0019] These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Figure **1** shows a structure of a multiplex voltage measurement apparatus **100** according to one embodiment of the present invention.

Figure **2** is a timing chart for illustrating an operation of the multiplex voltage measurement apparatus **100** shown in Figure **1.**

Figure **3** shows a structure of a conventional multiplex voltage measurement apparatus **300.**

Figure **4** is a timing chart for illustrating an operation of the conventional multiplex voltage measurement apparatus **300.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Hereinafter, a multiplex voltage measurement apparatus **100** according to one embodiment of the present invention is described with reference to Figure **1.**

[0022] In Figure **1,** like elements are indicated by like reference numerals used for the multiplex voltage measurement apparatus **300** of Figure **3,** and detailed descriptions thereof are omitted.

[0023] The multiplex voltage measurement apparatus **100** measures each of five serially-connected voltage sources **V1-V5.**

[0024] As shown in Figure **1,** the multiplex voltage measurement apparatus **100** includes: voltage detection terminals **T1-T6** connected to the five voltage sources **V1-V5;** a capacitor **3** having a first terminal **3A** and a second terminal **3B**; a first sample switch **1** formed by switches **S1, S3,** and **S5** for selectively connecting any of the odd-numbered voltage detection terminals **T1, T3,** and **T5** to the first terminal **3A** of the capacitor **3**; a second sample switch **2** formed by switches **S2, S4,** and **S6** for selectively connecting any of the even-numbered voltage detection terminals **T2, T4,** and **T6** to the second terminal **3B** of the capacitor **3;** a voltage measurement circuit **5** for measuring the voltage between the first terminal **3A** and the second terminal **3B;** a third sample switch **4** formed by switches **4a** and **4b** for connecting the first terminal **3A** and the second terminal **3B** of the capacitor **3** to the voltage measurement circuit **5;** and a polarity control circuit **6** for controlling opening/closure of the first sample switch **1,** the second sample switch **2,** and the third sample switch **4.**

[0025] In the multiplex voltage measurement apparatus **100,** the first sample switch **1** and the second sample switch **2** select one of the voltage sources **V1-V5** while the third sample switch **4** is open. Then, the first sample switch **1** and the second sample switch **2** are opened, and the third sample switch **4** is then closed. Such a process is repeated, whereby the voltages of the respective voltage sources **V1-V5** are measured.

[0026] In this example, five voltage sources **V1-V5** and six voltage detection terminals **T1-T6** are provided, but the number of voltage sources and the number of

voltage detection terminals are not limited thereto. The present invention can be practiced so long as N voltage sources and (N+1) voltage detection terminals are provided.

[0027] An operation of the multiplex voltage measurement apparatus **100** is now described with reference to Figure **1.** In the case of measuring the voltage of the voltage source **V1,** the switches **S1** and **S2** are closed while the third sample switch **4** is open, whereby the capacitor **3** is charged with the voltage of the voltage source **V1.**

[0028] Then, the switches **S1** and **S2** are opened, and the third sample switch **4** is closed, whereby the voltage of the voltage source **V1** is measured by the voltage measurement circuit **5.** At this time, the polarity of the first terminal **3A** of the capacitor **3** is positive, and the polarity of the second terminal **3B** of the capacitor **3** is negative.

[0029] In the case of measuring the voltage of the voltage source **V2,** the switches **S2** and **S3** are closed while the third sample switch **4** is open, whereby the capacitor **3** is charged with the voltage of the voltage source **V2.**

[0030] Then, the switches **S2** and **S3** are opened, and the third sample switch **4** is closed, whereby the voltage of the voltage source **V2** is measured by the voltage measurement circuit **5.** At this time, the polarity of the first terminal **3A** of the capacitor **3** is negative, and the polarity of the second terminal **3B** of the capacitor **3** is positive.

[0031] Thus, the polarity of the capacitor **3** in the case of measuring the voltage source **V1** is opposite to that in the case of measuring the voltage source **V2.**

[0032] In the case of measuring the voltage of the voltage source **V3,** the switches **S3** and **S4** are closed while the third sample switch **4** is open, whereby the capacitor **3** is charged with the voltage of the voltage source **V3.** At this time, the polarity of the first terminal **3A** of the capacitor **3** is positive, and the polarity of the second terminal **3B** of the capacitor **3** is negative, i.e., these polarities are the same as those when the voltage of the voltage source **V1** was measured.

[0033] Similarly, when the voltage of the voltage source **V4** is measured, the polarity of the first terminal **3A** of the capacitor **3** is negative, and the polarity of the second terminal **3B** of the capacitor **3** is positive. In the case of measuring the voltage of the voltage source **V5,** the polarity of the first terminal **3A** of the capacitor **3** is positive, and the polarity of the second terminal **3B** of the capacitor **3** is negative.

[0034] Thus, the polarity of the voltage to be applied from the voltage source **V1, V3,** or **V5** to the capacitor **3** is opposite to that of the voltage to be applied from the voltage source **V2** or **V4** to the capacitor **3.**

[0035] Now, a case where the voltage sources **V1-V5** are repeatedly measured in the order of **V1, V2, V3, V4,** and **V5** will be considered.

[0036] When the voltage source **V1** is measured after the voltage source **V5** has been measured, if one of the switches **S1** and **S2** is out of order so that it cannot be closed, the capacitor **3** cannot be charged with the voltage of the voltage source **V1.** That is, the voltage of the voltage source **V5** is left in the capacitor **3.** Moreover, the polarity of the capacitor **3** when the voltage source **V1** is measured is the same as that when the voltage source **V5** is measured. Thus, although the electric charge of the capacitor **3** is discharged with the lapse of time and, accordingly, the voltage value of the capacitor **3** varies, the voltage measurement circuit **5** erroneously measures the voltage of the voltage source **V5.** Therefore, the voltage measurement circuit **5** misreads a voltage value when one of the switches **S1** and **S2** is out of order so that it cannot be closed. Furthermore, the multiplex voltage measurement apparatus **100** cannot detect such a failure.

[0037] According to the present embodiment of the present invention, as shown in Figure **2,** the operation of the multiplex voltage measurement apparatus **100** is controlled by the polarity control circuit **6** such that the voltage of the voltage source **V4** is measured again after the voltage of the voltage source **V5** has been measured and before the voltage of the voltage source **V1** is measured **(V1 → V2 → V3 → V4 → V5 → V4 → V1 → V2).**

[0038] The polarity of the capacitor **3** in the case of measuring the voltage source **V4** is opposite to that in the case of measuring the voltage source **V1** or **V5.** Thus, the polarity of the capacitor **3** is inverted at every measurement.

[0039] When the voltage of the voltage source **V4** is measured after the voltage of the voltage source **V5** has been measured, the polarity of the capacitor **3** changes to the opposite polarity. Although the polarity of the measured voltage value for the voltage source **V4** is opposite to that for the voltage source **V5,** a correct voltage value can be obtained by inverting the polarity of the measured voltage value in the voltage measurement circuit **5.**

[0040] Assume that the voltage measurement circuit **5** obtains the voltage of the voltage source **V5** as a positive value and the voltage of the voltage source **V4** as a negative value. If the switch **S4** or **S5** is out of order so that it cannot be closed, the capacitor **3** cannot be charged with the voltage of the voltage source **V4,** i.e., the voltage of the voltage source **V5** remains in the capacitor **3.** Therefore, the voltage measurement circuit **5** obtains a positive voltage value. Thus, breakage of the switch **S4** or **S5** can be detected and, accordingly, an erroneous measurement can be prevented.

[0041] This is the same when the voltage of the voltage source **V1** is measured after the measurement for the voltage source **V4.**

[0042] As described hereinabove, according to this embodiment of the present invention, the polarity control circuit **6** controls the first sample switch **1,** the second sample switch **2,** and the third sample switch **4** such that voltages having opposite polarities are alternately stored in the capacitor **3.** With such a control arrange-

ment, when the multiplex voltage measurement apparatus **100** obtains voltage values of the same polarity in succession, the multiplex voltage measurement apparatus **100** can determine that there is a broken switch.

[0043] Thus, according to the present invention, there is provided a multiplex voltage measurement apparatus which does not measure an erroneous voltage even when one of sample switches is broken so that it cannot be closed.

[0044] Furthermore, according to the present invention, there is provided a multiplex voltage measurement apparatus which can detect a failure in an operation of one of the sample switches.

[0045] Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

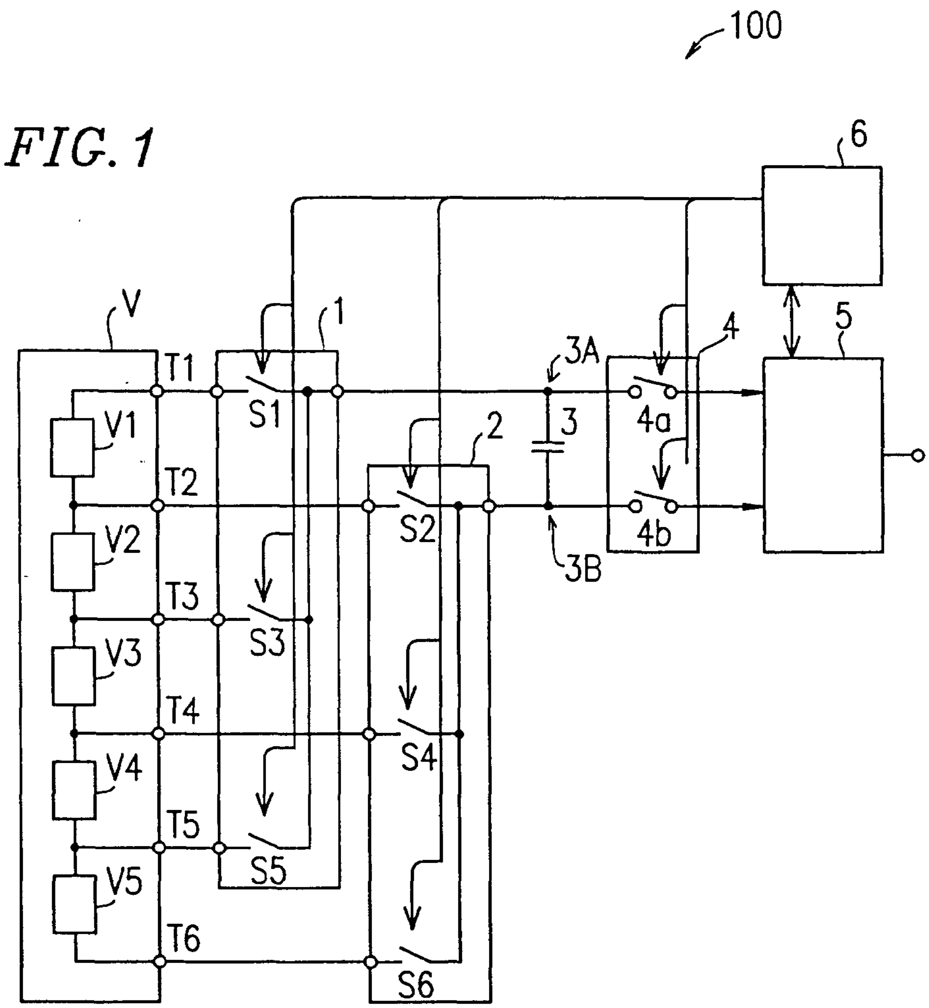
Claims

1. A multiplex voltage measurement apparatus, comprising:

    (N+1) voltage detection terminals connected to N serially connected voltage sources;
    a capacitor which is charged with a voltage value of any of the N voltage sources;
    a first sample switch for selectively connecting odd-numbered voltage detection terminals among the (N+1) voltage detection terminals to a first terminal of the capacitor;
    a second sample switch for selectively connecting even-numbered voltage detection terminals among the (N+1) voltage detection terminals to a second terminal of the capacitor;
    a voltage measurement circuit for measuring the voltage value stored in the capacitor;
    a third sample switch for connecting the first terminal and the second terminal of the capacitor to the voltage measurement circuit; and
    a polarity controller for controlling the first and second sample switches such that one of the N voltage sources is selected while the third sample switch is open.

2. A multiplex voltage measurement apparatus according to claim 1, wherein the polarity controller allows the first and second sample switches to sequentially select among the N voltage sources in a one-by-one manner such that the capacitor is alternately charged with voltage values having opposite polarities.

FIG. 1


100
6
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2
3A
3
4
T1
T2
T3
T4
T5
T6
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3B

FIG.2

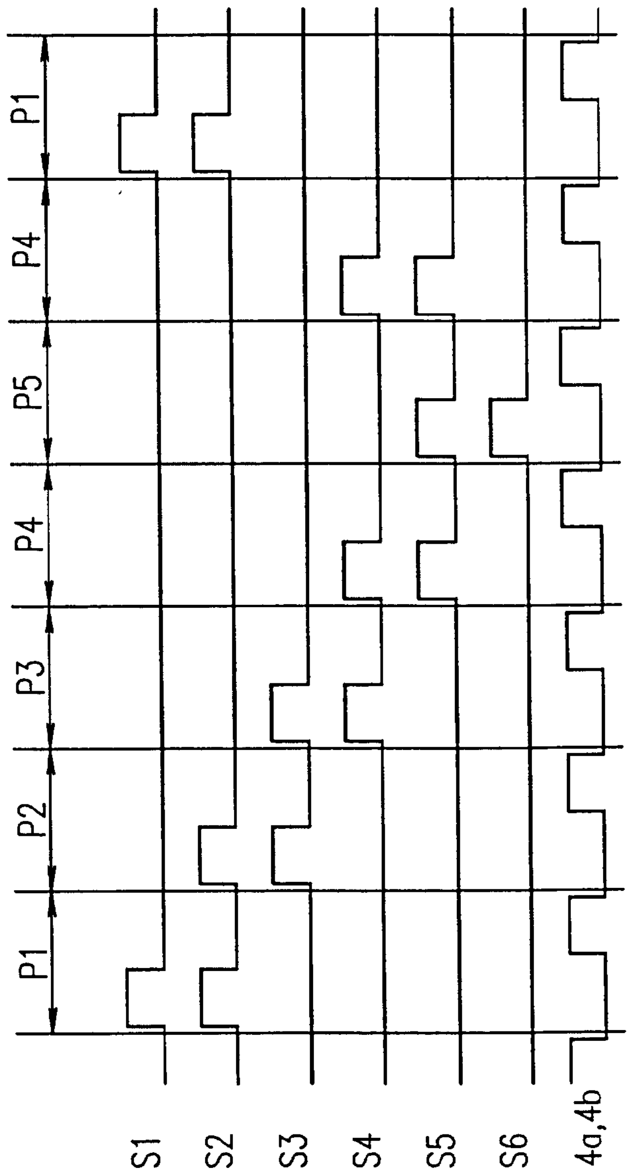


FIG. 3

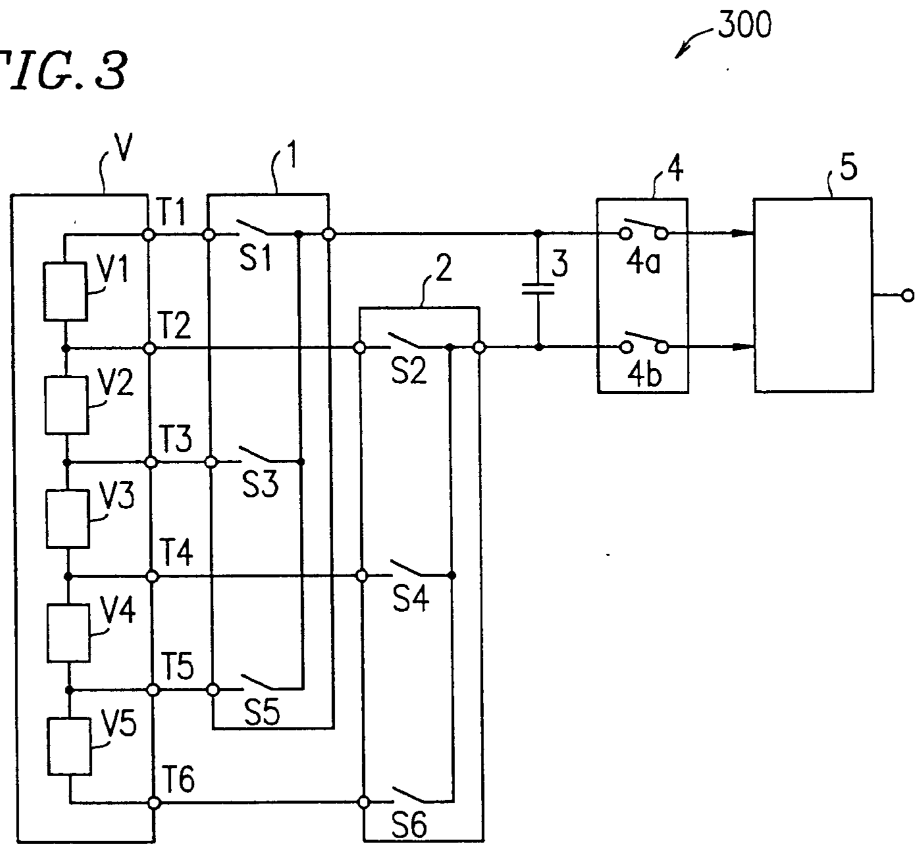
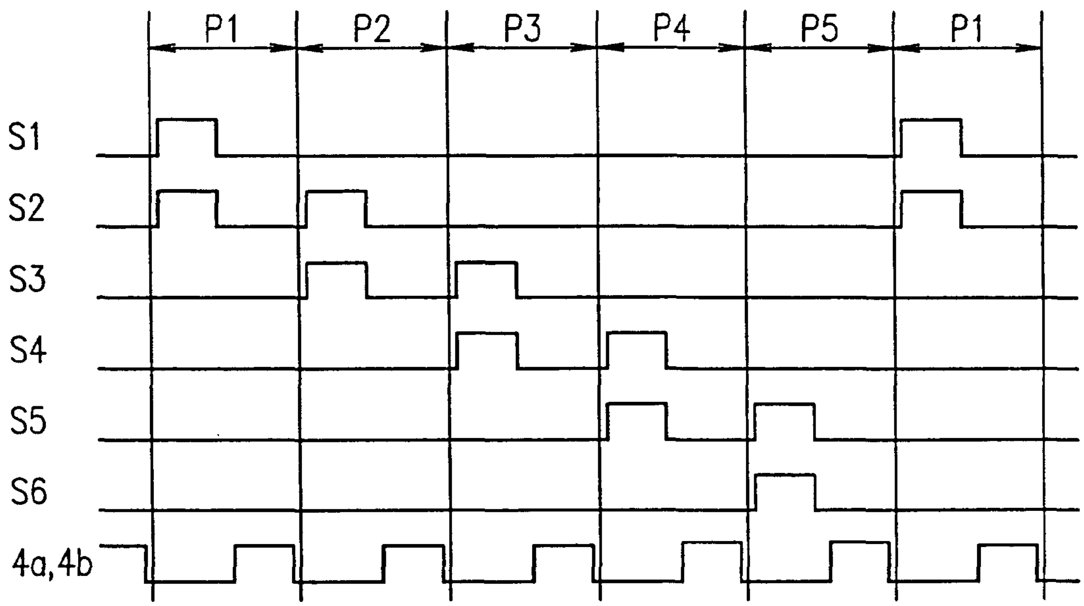


FIG. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 01 10 8602

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 914 606 A (BECKER-IRVIN CRAIG H) 22 June 1999 (1999-06-22) * column 6, line 34 - line 43; claims 1,17 *	1	G01R31/36
A	US 5 808 469 A (KOPERA JOHN J C) 15 September 1998 (1998-09-15) * column 2, line 60 - column 3, line 35; claims 1,4,20 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
G01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 July 2001	Six, G

CATEGORY OF CITED DOCUMENTS

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04-07-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5914606 A	22-06-1999	NONE	
US 5808469 A	15-09-1998	US 5646534 A	08-07-1997

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